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TC 1700BACKGROUND OF THE INVENTION

The subject of the present invention is an improvement to methods for producing mechanical parts and objects, particularly prototypes, from a specific computer-aided design, to elemental laminations produced by such methods, and to prototypes obtained by the assembly of such elemental laminations.

Such methods generally comprise a ~~of the type comprising the successive series of steps including manufacturing the phases of:~~

- [[ - ]] ~~manufacturing parts in elemental layers or laminations;~~
- [[ - ]] ~~building laminations, building up a~~ [[the]] collection of the layers, and assembling layers;
- [[ - ]] ~~assembling the layers to form the part, wherein the~~
- [[ ; ]]

~~said laminations~~ result ~~resulting~~ from a prior breakdown of the part along plural planes and in one or more defined steps.

~~The invention is also aimed at the elemental laminations thus produced, and at the prototypes obtained by assembling said elemental laminations.~~

One [[A]] rapid prototyping method of this general type is [[was]] the subject of European Patent EP-0 585 502-B1, the content of which is incorporated herein ~~entirely~~ by [[way of]] reference, which [[and]] is known by the name "STRATOCONCEPTION" (a registered trademark ~~trade mark~~).

The "STRATOCONCEPTION" [[This]] method is entirely satisfactory within the limits of the applications specified in EP-0 585 502-B1 ~~that patent, in which~~ the various laminations are essentially ~~being~~ positioned and assembled using inserts, the shape and position of which are also determined [[also]] by ~~specific software.~~

~~The fact of providing software. However, because the~~ inserts for the assembly are provided on the inside of the structure, in the case of parts of a certain thickness, ~~nonetheless makes~~ the implementation process, which in other respects is very flexible and effective, is somewhat ~~cumbersome.~~

~~Furthermore cumbersome. Moreover, it is difficult not~~ possible ~~easily~~ to provide inserts on the inside of the structure ~~for in the case of~~ laminations having a [[whose]] working cross-section (thickness of the final part) which is small. Such small ~~, which~~ laminations are needed for obtaining very fine, and therefore more precise [[,]] modeling, or for producing parts whose complex structure entails a breakdown passing through laminations of a very small lateral thickness.

#### SUMMARY OF THE INVENTION

The object of the present invention is to provide ~~propose~~ a rapid prototyping method of the type ~~method according to the~~

generally described in European Patent ~~concept of patent~~ EP-0 585 502 that also makes it possible, if required, not to use inserts for [[the]] internal assembly of the laminations to each other and for [[their]] positioning the inserts with respect to each other.

According to the present invention, this can be achieved ~~result is obtained~~ with a method for producing mechanical parts and objects, particularly prototype parts ~~prototypes~~, from a specific computer-aided design which includes ~~of the type~~ ~~comprising~~ the successive steps of manufacturing the ~~phases of:~~

- [[ -]] ~~manufacturing~~ parts in elemental layers or ~~laminations~~;
- [[ -]] ~~building~~ laminations, building up the collection of ~~layers~~;
- [[ -]] assembling layers, and assembling the ~~layers~~;

~~said~~ layers, wherein the laminations result ~~resulting~~ from a prior breakdown of the part along plural planes and in one or more defined steps. ~~The~~ ~~, characterized in that the~~ unitary laminations are determined by a [[the]] breakdown of the part, employing software, and are machined to include a ~~accordingly~~, ~~essentially comprise:~~

- [[ - a]] central portion effectively corresponding to a [[the]] lamination with the desired shape and desired thickness for obtaining the finished [[part,]]
- [[ - an]] part, an outer portion of roughly the same thickness [[,]] at least partially surrounding the [[said]]

central ~~portion,~~

[[~~-~~]] ~~frangible portion, and frangible bridges connecting the~~  
[[said]] central and outer portions ~~together.~~

~~The together.~~ The laminations are then put together, either by superposition or by shoring up the various laminations, so that the outer portions of each lamination form ~~finally forming~~ a ~~kind of~~ supporting surround enclosing the reconstructed part, [[to]] which are [[it is]] connected by the frangible bridges.

It will be understood that the part is broken down and assembled systematically, through the use of the specific software, which automatically positions and provides the bridges, the posts, and the inner or outer ~~inserts.~~

~~Thus~~ inserts, so the positioning and holding inserts are added to the outer surround. The [[These]] inserts allow the laminations to be positioned indirectly, by mounting and assembly (for example, but without ~~implying any~~ limitation, by ~~bonding~~).

The bonding). The supporting surround is then easily removed, because of the frangible bridges, once the laminations have been positioned and assembled.

The surround will enclose the final part from the smallest distance, for reasons of precision of assembly and economy of

material, which will in all instances ~~[[will]]~~ necessitate a pressing ~~by clamping.~~

~~The~~ of the assembly by clamping. This pressing system can ~~[[may]]~~ be external, for example, using ~~[[with]]~~ a mounting plate, or built in ~~in-built~~, with the surround being self-supporting.

The invention will be better understood from ~~with the aid~~ of the description given hereinafter, with reference to the following ~~appended~~ drawings, ~~in which:~~

#### BRIEF DESCRIPTION OF THE DRAWINGS

~~[[ - ]]~~ Figure 1 ~~figure 1 illustrates~~ schematically illustrates ~~in the form of a diagram the principle of~~ implementation of the method known as "STRATOCONCEPTION". ~~stratoconception;~~

~~[[ - ]]~~ Figure 2 ~~figure 2 illustrates~~ schematically illustrates a part which has been reconstructed from elemental laminations with an outer surround, in accordance with ~~according to~~ the present invention. ~~[[ ; ]]~~

~~[[ - ]]~~ Figures ~~figures~~ 3A to 3F illustrate ~~depict~~ alternative forms of the frangible bridges and ~~[[ of ]]~~ the outer surrounds. ~~[[ ; ]]~~

~~[[ - ]]~~ Figure 4 illustrates ~~figure 4 depicts~~ the part shown in Figure ~~of figure~~ 2 with a self-supporting, holding and assembly

structure. [[;]]

[[ - ]] Figure 5 illustrates figure 5 depicts an alternative form of the part shown in Figure of figure 2, with a holding and assembly structure that includes involves a mounting plate. [[;]]

[[ - ]] Figures figures 6 and 7 illustrate depict an alternative form of the part shown in Figure of figure 2, with [[an]] alternative forms of the assembly structures shown in Figures 4 and 5. ~~of the same type as that of figures 2 and 5;~~

[[ - ]] Figure figure 8 is a partial, cross-sectional view that illustrates [[,]] ~~in part section,~~ one possible possibly assembly, with external inserts, for complex shapes and thin laminations.

#### DETAILED DESCRIPTION OF THE INVENTION

~~Reference is made first of all to figure 1.~~

Figure 1 schematically illustrates a process for producing a mechanical part that is to be prototyped, from a specific, computer-aided design. ~~Using The general principle consists, by using~~ specific software (1), the in cutting a part that is to be prototyped is cut into laminations. The [[, the]] laminations are [[being]] machined by rapid micromachining (2), which is the machine being controlled by the software (1), from a material (3) in sheet form.

~~The form.~~ The various laminations are assembled into a collection (4) of comprising inserts (5) to finally obtain the ~~[[a]]~~ prototype (6), after finishing.

The software (1) governs selection of the ~~choice of~~ planes for the slicing/stratification of the laminations ~~[[plane]]~~, the ~~[[of]]~~ lamination profiling ~~profile~~ step, any scaling ~~of scale~~ ratios, the ~~[[of]]~~ precision and ~~[[of]]~~ the position for ~~of the~~ inserts.

~~Once the inserts.~~ Once the various sheet parameters (i.e., dimensions, material, choice of direction, ~~[[of]]~~ clearance) and the machining parameters (i.e., cutting rate, cutter diameter, etc.) have been input, the entire machining program is transmitted by the software (1) which controls the cutting robot (i.e., the apparatus (2) which performs the micromachining).

~~Reference will now be made to figure 2.~~

According to the present invention, and referring now to Figure 2, the foregoing method ~~implemented~~ makes it possible to obtain a plurality ~~multitude~~ of elemental laminations (7) which, once assembled, reproduce the part to be prototyped ~~reproduced~~ (8) connected to an outer surround (9) by bridges ~~(10).~~

~~It~~ (10). It will be understood that, following appropriate assembly, ~~[[the]]~~ elimination of the surround (9) and of the bridges (10) ~~produces results in the obtaining of~~ the final prototype part (8). ~~, particularly the prototype.~~

The laminations (7) can ~~[[may]]~~ have different and highly varied geometric shapes at the bridges (10). and for the elements (11) that finally form the outer surround ~~(9).~~

~~Various~~ (9). Various alternative forms, which are provided as non-limiting examples, ~~are shown depicted non-limitingly~~ in Figures ~~figures~~ 3A to 3F.

Figure 3A shows ~~depicts~~ three alternative forms of bridges that can be formed to develop a weakened ~~[[at the]]~~ zone of ~~weakness~~ (12). where subsequent cutting will occur.

In Figure ~~figure~~ 3B, it will be noted that the ~~distribution~~ of the bridges, in the ~~[[for]]~~ example shown, three such bridges, can ~~of these, may~~ be uniformly distributed around the periphery of the central portion (i.e., in this particular example, instance at 120°).

In Figure ~~figure~~ 3C, the alternative form shown includes ~~consists in the~~ elements (11) that are formed as ~~[[being]]~~ rounded and enveloping sectors (13).



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In Figure figure 3D, the three sectors ~~such as~~ (13) ~~of~~ Figure 3C are joined together to form a single collar (14).

In Figure 3E, the single collar (14) of Figure 3D ~~[[which]]~~ fully surrounds the part in a ring (15) ~~in the depiction of figure 3E.~~

Finally, in Figure figure 3F, the orifices (16') ~~present~~ in each of the elements, which are ~~structure and~~ used to position and to assemble the bridges together, are ~~[[will]]~~ no longer ~~[[be]]~~ circular orifices (16), as they were in ~~[[the]]~~ previous examples. Instead, the orifices (16') figures, but will have a polygonal geometric cross-section. This then ~~[[,]] which will~~ allows the ~~[[their]]~~ number of orifices in a single one and the same lamination to be limited, while providing ~~[[for]]~~ the same precise positioning.

The laminations are assembled on shafts (17). In Figure of ~~which, in figure 4, a series of there are~~ three such shafts (17) are shown. As a non-limiting ~~[[,]] these for~~ example, the shafts (17) have but non-limitingly, having wing nuts (18) for clamping an assembly together. In this illustrated example, instance, the structure is self-supporting.

In Figure figure 5, ~~there are~~ two shafts (21) are fixed on a mounting plate (19) equipped with bores (20).

~~This type of (20).~~ Such an assembly can ~~may also~~ be used when the assembly method is being implemented systematically, ~~[[and,]]~~ for example, for teaching or ~~[[even]]~~ recreational purposes.

Figures ~~in-figures~~ 6 and 7 show ~~[[, the]]~~ structures that are identical to the structures shown in Figures ~~those of figures~~ 4 and 5, except that there is only ~~with just~~ one shaft ~~such as~~ (i.e., 17', 21'), and one insert-type rod (22), which is ~~of the~~ insert type ~~to provided~~ for purposes of positioning.

Finally, Figure ~~figure~~ 8 illustrates ~~depicts~~ a complex alternative form having ~~[[with]]~~ inserts (23) which are suitable for extremely thin laminations. For example, each of the inserts (23) can involve only ~~involving just~~ a few contiguous laminations.

As previously indicated, ~~Of course,~~ each elemental lamination will be machined by a micromachining process ~~in accordance with the generally method~~ known as "STRATOCONCEPTION". If "Stratoconception" ~~[[,]] possibly with turning over, if~~ necessary, in the course of the machining process, such machining can include an inversion according to the method which is described in U.S. Patent Application No. 09/856,208, which was a ~~patent application~~ filed simultaneously herewith ~~by the applicant~~ and ~~[[to]]~~ which is expressly incorporated herein by reference ~~is~~

made.

The ~~[[This]]~~ method of the present invention allows the manufacture of prototype ~~prototypes of~~ parts having ~~[[of]]~~ very complex shapes, very rapidly and at a low cost. The method of the present invention ~~[[It]]~~ also opens interesting opportunities for teaching and recreational applications.